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ABSTRACT

The purpose of this study was to determine whether a group of volunteer subjects could produce and maintain a pedalling cadence within an acceptable range of error. This, in turn, would aid in determining the reliability of pedalling rates employed in work tests on the bicycle ergometer. Forty male college students were randomly given four different treatments. These consisted of pedalling the ergocycle for six minutes at 40, 50, 60, or 70 revolutions per minute. Surface electrodes were applied to the subject's right leg. A metronome was set in front of the subject so that he could pedal the ergocycle in cadence with it. The metronome cadence was then compared with the EMG Trace to determine whether the subject had maintained the correct pedalling cadence. No significant difference was found. (PB)

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THE RELIABILITY OF PEDALLING RATES EMPLOYED IN WORK TESTS ON THE BICYCLE ERGOMETER

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INTRODUCTION

Obtaining human subjects for studies of exercise employing the bicycle ergometer presents a plethora of variables to be brought under control. The mechanical ergometer requires the maintenance of a specific pedalling rate to accurately maintain a given work load, and it is critical that the subjects being tested are able to perform accordingly. Training subjects to eliminate the possibility of cadence variability is not convenient, and it is generally more desirable to accept volunteers from a defined population. However, this procedure may add to the experimental variability.

It was therefore the purpose of this study to determine whether a group of volunteer subjects could produce and maintain a pedalling cadence within an acceptable range of error.

EXPERIMENTAL PROCEDURE

Forty untrained subjects between the ages of 18 and 29 years volunteered their services to the project. The group consisted of University of North Dakota students in Physical Education classes during the 1969 Summer Session. All had used bicycles at some time during their lives, but none had ever performed a test on a bicycle ergometer.

The subjects were randomly assigned to one of four different treatments. The treatments consisted of pedalling the Monark Bicycle Ergometer for a duration of six minutes at one of four different rates -- 40, 50, 60 or 70 revolutions per minute. The tests were completed over a four-day period. Minimum pre-test instructions were given each subject, and the subjects were not encouraged to ask questions. However, care was taken to

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clearly explain the purpose of the test and explain how the data would be compared. The Franz electric, audio-visual metronome was mounted on a front support of the ergocycle in full view of the subject. The metronome was set at twice the desired pedalling rate so that the subject would extend one leg, either the right or left, on each signal. Thus, an 80 signal metronome cadence was used for a 40 RPM test. The same procedure was used for the 50, 60 and 70 RPM tests.

The metronome was calibrated at each cadence prior to the study. To pursue this procedure, the metronome was switched on and allowed to warm-up for five minutes at the cadence which would be calibrated. At the end of the warm-up phase a visual count of the metronome cadence was begun. The count was recorded at one-minute intervals for six consecutive minutes, the duration of the impending tests. This procedure was repeated twice on consecutive days for each of the four metronome cadences. A test of the visual counts over the two trials indicated no significant difference at the .01 level.

The mean value of the visual metronome counts represented pedalling rates of 38.5, 48.2, 58.3 and 68.0 revolutions per minute. These values represented an error in metronome performance over the two trials of less than 1%. In light of this evidence, it appeared justifiable to set the metronome cadence for 40, 50, 60 and 70 RPM's and base the analysis of the subjects' performance on the mean values of the visual counts.

Three surface electrodes were applied to the Vastus Medialis muscle of the subjects' right leg. A Physiograph Six recorder was employed to record the action potential produced during contraction of the muscle while pedalling the ergocycle. (See figure 1). Each recorded contraction

thus indicated one revolution of the ergocycle pedal.

The subject mounted the ergocycle, which was preset at a resistance of two kiloponds for all tests, and pedalled at the randomly assigned rate for a period of six minutes. Each subject began the test with the right leg in full extension; thus, the first contraction appeared on the trace at the end of the first revolution of the pedal arms.

RESULTS AND DISCUSSION

The minute by minute RPM's were counted manually from the EMG trace and were recorded for each subject over the four tests. A Chi Square analysis was applied to the data to test the significance of the difference in pedalling rates between the calibrated metronome count and the EMG trace count. To accomplish this analysis, the calibrated metronome count for each test (38.5, 48.2, 58.3 and 68.0 RPM's) was identified as the theoretical frequency, and the subject's actual pedalling rate was identified as the observed frequency. Chi Square estimates were calculated for each of the four tests.

A Chi Square value of 69.92 was required for rejection of the null hypothesis of 45 degrees of freedom at the .01 level. The calculated Chi Square values were 2.779 for the 40 RPM test, 2.199 for the 50 RPM test, 14.981 for the 60 RPM, and 18.456 for the 70 RPM test; thus, the null hypothesis of no difference between the revolutions of the pedal arms and the metronome signals was retained as tenable for the four rates of pedalling.

Figure 2 illustrates the trend established by the calculated Chi Square values; that is, a gradual increase in the discrepancy between the metronome cadence and the pedalling rate of the subject. It appears noteworthy that as the metronome cadence increased, the subjects experienced increasing

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TABLE I. PERCENT ERROR FOR THE REVOLUTIONS PER MINUTE TEST BASED ON THE CALIBRATED METRONOME CADENCE.

	RPM TEST			
TIME (mins)	40.0	50.0	60.0	70.0
0-1	1.3%	1.4%	4.1%	5.3%
1-2	.3%	1.2%	3.7%	3.5%
2-3	.5%	1.4%	2.9%	4.3%
3-4	1.3%	1.5%	3.2%	4.6%
4-5	1.0%	1.2%	3.3%	3.5%
5-6	.3%	1.3%	3.7%	1.9%

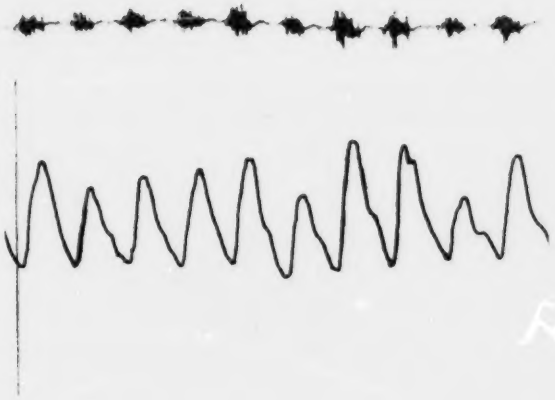

FIGURE 1. EMG TRACE AND EMG INTEGRATED TRACE TAKEN FROM THE VASTUS MEDIALIS MUSCLE OF A SUBJECT'S RIGHT THIGH WHILE PEDALLING THE ERGOCYCLE. THIS TRACE SHOWS TEN COMPLETED REVOLUTIONS OF THE PEDAL ARMS.

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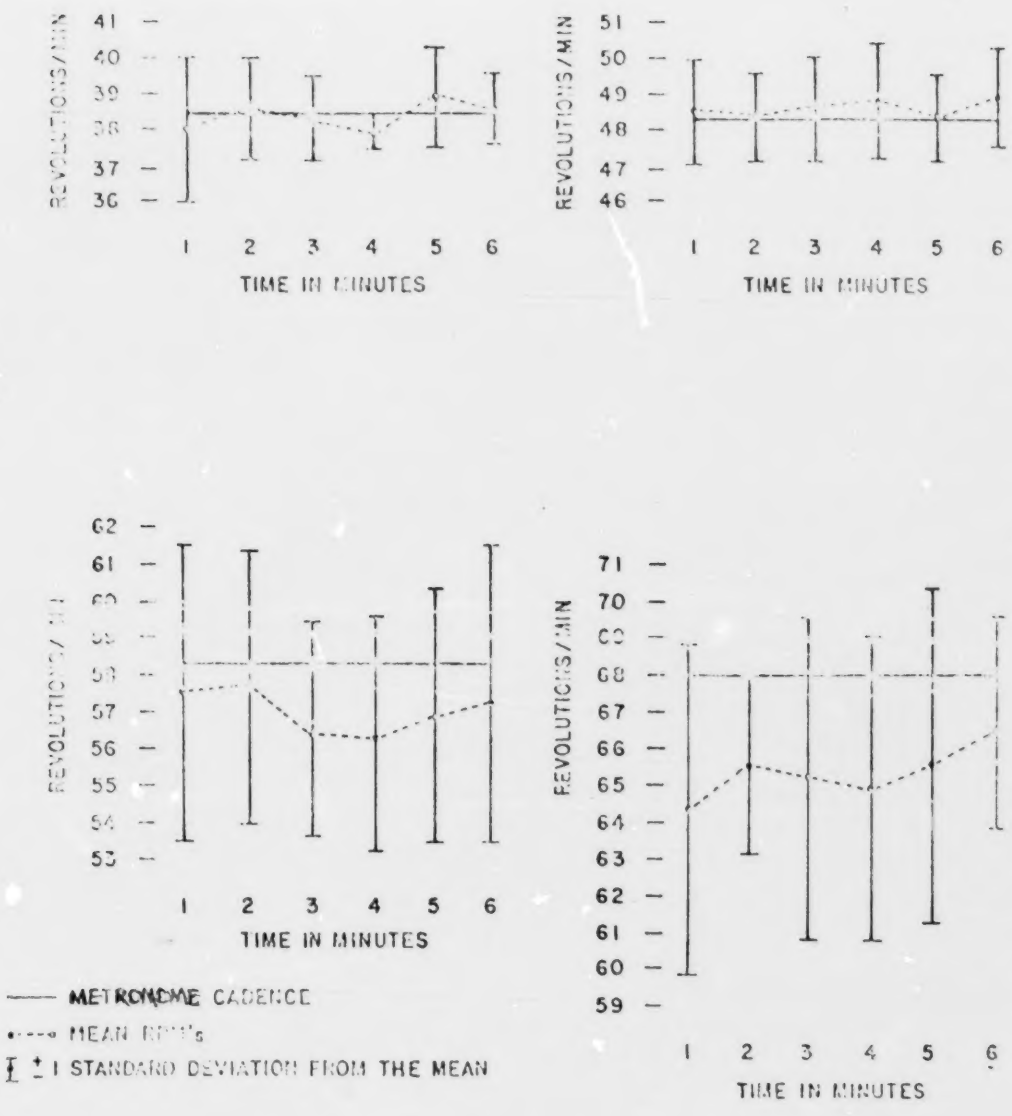

FIGURE 2. THE MEAN REVOLUTIONS PER MINUTE ± 1 STANDARD DEVIATION FOR 4 METRONOME CADENCES.

difficulty in maintaining the required revolutions per minute. Whereas the 40 and 50 RPM tests indicate an error of less than 2%, the 60 RPM test error increased to a maximum of 3.3% and the 70 RPM test error increased to a maximum of 5.3%. (See Table 1).

In revolutions per minute, these errors represent discrepencies of less than one RPM for the 40 and 50 RPM tests; 2.4 RPM's for the 60 RPM test, and 3.6 RPM's for the 70 RPM test.

CONCLUSION

It may be concluded that on the basis of these data and in consideration for the assumptions and limitation of this study, inexperienced subjects were able to maintain a constant pedalling rate with minimal error.